Joining of Tungsten Cermet Nuclear Fuel, Phase II

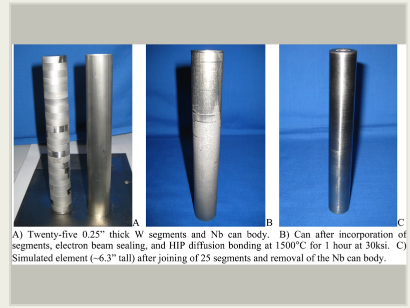
Completed Technology Project (2017 - 2022)

Project Introduction

Nuclear Thermal Propulsion (NTP) has been identified as a critical technology needed for human missions to Mars and beyond due to its increased specific impulse (Isp) as compared to traditional chemical propulsion systems. Recently, the Game Changing Development (GCD) Program, which is a partnership between NASA, DOE, and industry, was initiated to evaluate the feasibility of a low enriched uranium (LEU) NTP system. A critical aspect of NTP is to develop a robust, stable fuel. One of the fuel configurations currently being evaluated is a W-UO2 cermet. Fabrication of full-size cermet elements (>20?) has proven to be difficult. As a result, the use of cermet segments to produce a full-size fuel element is of interest. However, techniques for joining the segments are needed. During Phase I, diffusion bonding techniques were developed for producing fuel elements from cermet segments. Microscopic examination and preliminary properties testing showed excellent joints were formed. For example, quantitative tensile testing of W samples produced at 1500C HIP with a Nb interfacial coating showed the failures were in the bulk W and not at the Nb-W interfaces. Therefore, the strength of the joints were greater than the strength of the bulk W material. Using the most promising fabrication methods, a 6.3' long simulated cermet fuel element comprised of twenty-five 0.25' thick segments was produced to demonstrate proof-of-concept. During the Phase II investigation, the HIP diffusion bonding process will be optimized for making W cermet based fuel elements. This will be accomplished by performing a process parameter-characterization-properties study. The optimized fabrication methods will then be used to make prototype fuel elements with W claddings and subscale fuel elements for delivery to NASA for hot hydrogen testing.

Anticipated Benefits

NASA applications that would benefit from this technology include Nuclear Thermal Propulsion (NTP) and Nuclear Electric Propulsion (NEP). For example, the proposed Phase II effort directly supports the goals of NASA's GCD Program. Initial NTP systems will have specific impulses roughly twice that of the best chemical systems, i.e., reduced propellant requirements and/or reduced trip time. During Phase II-X and III, full-size full elements will be fabricated for testing in NTREES. Potential NASA missions include rapid robotic exploration missions throughout the solar system and piloted missions to Mars and beyond, where power from solar panels becomes more difficult to obtain.Both government and commercial entities in the following sectors would benefit from the development refractory metal coatings and diffusion bonding: defense, material R&D, nuclear power, aerospace, propulsion, automotive, electronics, crystal growth, and medical. Targeted commercial applications include high temperature-corrosion resistant claddings for nuclear fuel rods, hot gas path rocket motors, net-shape fabrication of refractory rocket nozzles, crucibles, heat pipes, and propulsion subcomponents; and advanced coating systems for x-ray targets, sputtering targets, turbines, and rocket engines.



Joining of Tungsten Cermet Nuclear Fuel, Phase II Briefing Chart Image

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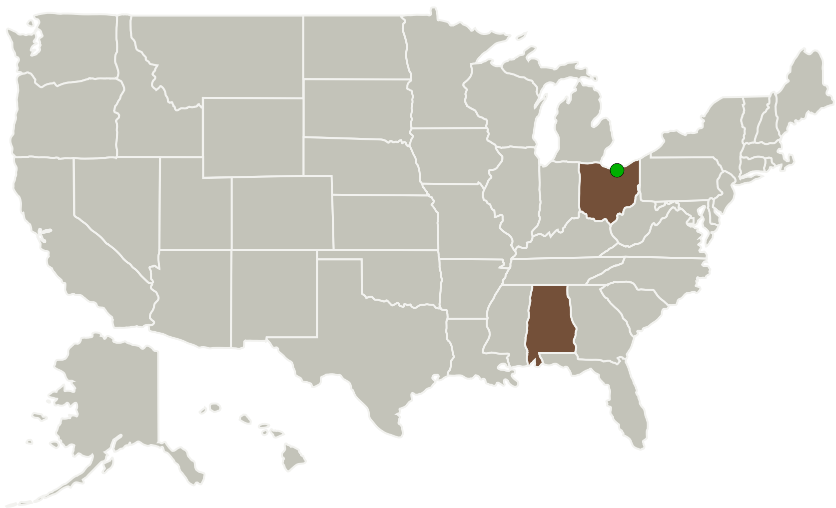
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Plasma Processes, LLC	Lead Organization	Industry Veteran-Owned Small Business (VOSB)	Huntsville, Alabama
Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio

Primary U.S. Work Locations	
Alabama	Ohio

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Plasma Processes, LLC

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

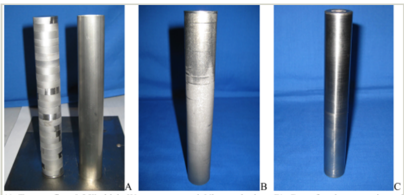
Project Managers:

Michael C Halbig
Matthew C Deans

Principal Investigator:

John Scott S O'dell

Images



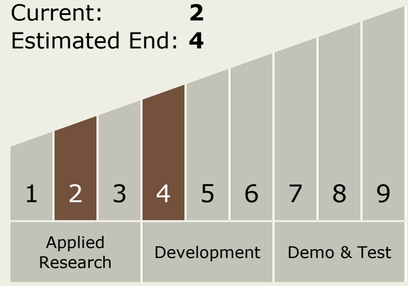
A) Twenty-five 0.25" thick W segments and Nb can body. B) Can after incorporation of segments, electron beam sealing, and HIP diffusion bonding at 1500°C for 1 hour at 30ksi. C) Simulated element (~6.3" tall) after joining of 25 segments and removal of the Nb can body.

Briefing Chart Image

Joining of Tungsten Cermet Nuclear Fuel, Phase II Briefing Chart Image *(https://techport.nasa.gov/image/130105)*

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **4**



Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System